SCIENTIA AGRICULTURAE BOHEMICA

Article

Navigating the COVID-19 pandemic supply-chain storms of agricultural firms in Ebonyi state, Nigeria

Daniel Chinedu NWAOGU[1]*, Miriam Oluchi GODWIN[1], Blessing Chidimma NWAOGU[2]

[1] Department of Agribusiness and Management, Alex Ekwueme Federal University Ndufu-Alike, Ebonyi state, Nigeria; danielchinedu32@gmail.com; miriammitchelle@gmail.com;

[2] Department of Psychology, Alex Ekwueme Federal University Ndufu-Alike, Ebonyi state, Nigeria; blessingchidimmanwaogu@gmail.com

* Correspondence: danielchinedu32@gmail.com (Nigeria)

Abstract: The COVID-19 pandemic ushered in a new era for businesses globally. This study examined how agricultural firms navigated the COVID-19 induced supply chains disruptions in Ebonyi, Nigeria. Multi-stage sampling technique was employed in selecting 450 agricultural firms across the state from where data were elicited with structured questionnaires and analyzed using descriptive statistics and the Seemingly Unrelated Regression (SUR). Findings showed that the pandemic severely disrupted supply-chain activities, leading to outrageous price inflations, transportation-logistics disruptions, labour shortages, supply-chain bottlenecks, significant decrease in agricultural firms' income and an increase in food insecurity. To mitigate these challenges, agricultural firms found alternative transportation and logistics solutions, diversified product offerings to meet changing demands and reduced labour requirements. The SUR estimates showed that production size, firm location, previous hazard experience hazard, product diversity, capital, social net benefits and operation risk influenced the firms' post pandemic survival. The pandemic led to business' shut down, severe movement restrictions with far-reaching devastating and lingering effects on the supply chain, economy and livelihood structure of the agricultural firms and populace at large. Firms must manage risks, maintain multi-layered diversification while government must provide robust social safety nets to enhance agricultural firms' resilience and survival prospects against systemic shocks.

Keywords: COVID-19; survival; livelihood; supply-chain; food security; production

Received for publication on January 25, 2026

Accepted for publication on April 04, 2026

1. Introduction

Agriculture stands as a cornerstone of Ebonyi State's economy, making substantial contributions to both its GDP and employment landscape (Anigbogu and Uzondu, 2018). The state's agricultural output encompasses key crops such as rice, yam, cassava, and vegetables (Onyeneke et al., 2021). The intricate supply chain for these agricultural goods encompasses multiple stages, ranging from planting and harvesting to processing, packaging, distribution, and eventual retail.

According to Oyim et al. (2023), agricultural productivity in Ebonyi is constrained by high costs of mechanized farming relative to manual labour and inadequate capital, which discourage mechanization and keep many farmers reliant on manual labour. In addition, limited storage and post-harvest facilities, inadequate infrastructure, including underinvestment in water and irrigation, dependence on rudimentary modes of transport and by bad roads, high transport costs further undermine agricultural production and food availability (Ogiji and Udoikah, 2025; Nnadozie et al., 2018). Ebonyi's budgetary allocations to agriculture have consistently fallen far below the Maputo Declaration benchmark of 10% of the annual budget, often under 3% and falling below 2% from 2018–2021, with even these meagre allocations not fully released (Ogbodo et al., 2023). Studies argue that such underfunding has hampered agricultural development and exacerbated food insecurity, unemployment, poverty and low revenue contribution from agriculture, indicating limited policy support capacity during crises.

Before COVID-19, most farmers in Ebonyi operated at smallholder scales, with rice farmers characterized as small-scale and heavily constrained by poor access to production credit, low productivity, and lack of timely access to improved seed and other inputs (Chidiebere-Mark et al., 2019). Inadequate capital, high cost of mechanized farming relative to manual labour, lack of investment in post-harvest processing and storage and poor infrastructure were all characteristics of the pre-COVID era, exposing the sector to external shocks. Commodity markets for smallholders were often informal and localized, with smallholders typically selling directly and personally to buyers rather than through structured channels (Hani, 2020).

Ebonyi's smallholder-dominated agricultural structure can act as both a vulnerability and a resilience factor. Evidence from Nigeria and other African countries shows that smallholders and agricultural SMEs relying on informal, localized markets were particularly exposed when COVID-19 containment measures restricted movement, reduced transport options and limited access to input and output markets, leading to declines in production, trading activities and farm incomes (Onyeaka et al., 2022).

At the same time, research across Africa finds that local networks and informal arrangements were central to coping. Smallholders and agricultural SMEs often survived by selling within their immediate communities, relying on local networks to reach customers, or diversifying livelihood activities (Dapilah et al., 2020). Such social networks and group memberships are associated with greater livelihood diversification and higher resilience to shocks, and pandemic-era studies show smaller agricultural SMEs using local networks and roadside or neighbourhood sales when formal channels were disrupted (Kadzamira et al., 2023).

However, the high cost of inputs, limited credit, and lack of infrastructure in Ebonyi restrict production cycles and adaptive capacity: farmers face poor access to production credit, high labour and input costs, and weak infrastructure, while reliance on erratic rainfall and limited or no irrigation infrastructure leads to uncultivated fields in the dry season and recurrent yield losses (Nwahia et al., 2020). These pre-existing constraints heighten vulnerability when shocks such as COVID-19 occur.

Agriculture is still largely practiced at the subsistent level by small-scale farmers, with low yields linked to traditional methods, misuse of modern technology and low credit access, including Ebonyi. By contrast, northern rice belts (e.g. Kano–Kaduna axis) have been focal areas for larger irrigated and mechanized rice schemes and commercial out-grower arrangements in national

rice-sector policy debates, which strengthen linkages to national markets (Nwahia et al., 2020), reflecting Ebonyi's weaker historical infrastructure and capital intensity.

Within Southeast Nigeria, however, Ebonyi shares similar COVID-19-induced food security challenges with neighbouring states: lockdowns, border closures and movement restrictions disrupted food crop production and food supply chains, reducing availability, accessibility and affordability of food (Munonye et al., 2022; Onyeaka et al., 2022). In Southeast Nigeria overall, lockdowns sent farmers off their farms, blocked inflows of food and livestock from other regions, drove up prices, and sharply worsened food security indicators.

According to Bitzer et al. (2024), national and cross-country studies on COVID-19 and agricultural food systems are often conducted at aggregate or multi-country scale, assessing national food security indicators or broad supply-chain resilience patterns rather than place-specific value-chain structures. This Ebonyi-focused study on COVID-19 pandemic highlights the value of sub-national, context-specific analysis of food supply chains and food security dimensions. This location-specific study will help reveal meso-level resilience mechanisms and institutional gaps in a marginal yet strategically important agrarian region, complementing more generalized national assessments (Bitzer et al., 2024). This study further contributes to existing literature by highlighting the unprecedented disruptions in local supply chains across various agricultural sectors in Ebonyi state. The over-reliance of the region on agriculture for sustenance predisposes it to supply chain disruptions and its attendant consequences such as labor shortages, transportation bottlenecks, market closures, and fluctuating prices (Reardon et al., 2021).

To this effect, the study answers the following questions:

i. Who are the major supply chain actors in the agricultural sector?
ii. How did COVID-19 disrupt the agricultural supply chain and to what extent?
iii. What mitigation strategies were employed by these agricultural firms to manage the disruptions?
iv. What are the social and economic implications of the pandemic on agripreneurs' income, food security and wellbeing?
v. What factors influenced the agricultural firms' post pandemic survival/recovery?

1.2 Theoretical and empirical considerations

1.2.1 Supply chain resilience theory

Supply chain resilience theory explains a firm's and supply network's ability to anticipate, absorb, adapt to, and recover from disruptions while maintaining core functions, emphasizing capacities such as robustness, redundancy, flexibility, and adaptability (Ali et al., 2017). This theory integrates perspectives from systems theory and organizational resilience literature, viewing resilience not only as stability but also as proactive adaptation and transformation (Ivanov, 2023). The COVID-19 pandemic exposed agricultural supply chains to severe shocks including movement restrictions, input shortages, labor constraints, and market volatility, highlighting the need for resilience in these sectors. Agricultural firms demonstrate resilience by reconfiguring sourcing channels, adjusting production schedules, diversifying markets, and adopting alternative distribution mechanisms (Ali et al., 2017). This framework is especially relevant in developing economies where supply chains tend to be fragmented and highly vulnerable to systemic shocks due to limited integration and resources (Takamuhabwa et al., 2015).

1.2.2 Business survival frameworks

Business survival frameworks focus on how firms withstand external shocks and remain operational during crises by leveraging critical resources, managerial competence, liquidity, innovation, and strategic flexibility, drawing from the resource-based view and dynamic capability theory (Senin et al., 2024). Firms' survival depends on deploying internal capabilities, utilizing external networks, and proactively responding to environmental uncertainty (Husni et al., 2025). These frameworks explain why some firms exit the market while others endure by emphasizing factors such as innovation ambidexterity, dynamic capabilities, and strategic awareness (Aldianto et al., 2021). Empirical studies highlight that managerial skills, business agility, and access to resources are crucial for short- and long-term survival under crisis conditions (Rahman et al., 2022).

1.2.3 Crisis management models

Crisis management models provide structured approaches to understanding organizational responses before, during, and after disruptive events, typically outlining phases such as crisis preparedness, response, recovery, and learning (Vasickova, 2020). According to the research, effective crisis management involves early warning systems, contingency planning, rapid decision-making, communication, and post-crisis adaptation to enhance organizational resilience. During the COVID-19 pandemic, many agricultural firms operated reactively due to limited preparedness for a global health emergency, highlighting gaps in crisis readiness (Singh & Chahal, 2015). Applying these models helps explain firm-level responses including operational adjustments, workforce restructuring, and adoption of emergency coping strategies aimed at mitigating supply chain disruptions (Lopez et al., 2023).

1.2.4 Risk assessment theories

Risk assessment theories focus on how organizations identify, evaluate, and manage uncertainty and potential losses by emphasizing risk perception, probability assessment, impact severity, and mitigation strategies (Aven, 2016). In supply-chain contexts, risks arise from production, logistics, markets, institutions, and external shocks such as pandemics, which increase complexity and uncertainty Liu et al., 2025). The COVID-19 pandemic heightened both perceived and actual risks across agricultural supply chains by disrupting input availability, transportation, demand, and pricing (Semenova & Sokolov, 2025). These theories provide a foundation for understanding how agricultural firms evaluate vulnerabilities and implement risk-reducing practices to enhance resilience and continuity (Aalabaf-Sabaghi, 2023).

1.3 Empirical review

The agricultural sector, a vital source of food security and economic stability, faced unique challenges during the pandemic. Studies have highlighted supply chain disruptions caused by labor shortages and logistics bottlenecks across various sectors, including manufacturing and food supply chains (Kanike, 2023; Deconinck et al., 2020). These disruptions led to reduced access to inputs, transportation constraints, and market closures, ultimately affecting food availability and prices (FAO, 2020; Swinnen and McDermott, 2020). Smallholder farmers, often the most vulnerable, experienced income losses and decreased livelihood resilience (Torero, 2020). Research by Glauber et al., (2020) investigated the pandemic's impact on global food trade and agricultural supply chains. They found that lockdowns, labor shortages, and transportation disruptions disrupted the flow of agricultural products, leading to concerns about food security and food price volatility. Swinnen and McDermott (2020) examined the resilience of agricultural supply chains during the pandemic. They

highlighted those disruptions in labor-intensive agricultural production and disruptions in logistics and trade had significant repercussions for the global food system.

Studies have also revealed specific insights into how the COVID-19 pandemic impacted agricultural supply chains at regional and national levels. For instance, research conducted by Reardon *et al.*, (2020) focused on the effects of the pandemic on agricultural markets in sub-Saharan Africa. They found that disruptions in transportation and marketing channels led to increased food prices and reduced access to agricultural inputs for farmers in the region. In another study, Aday and Aday (2020) investigated the impact of the pandemic on the global food supply chain, emphasizing the challenges faced by perishable food producers. They noted that disruptions in international trade and export restrictions affected the ability of agricultural producers to access global markets. Furthermore, empirical studies by Espitia et al. (2020) and World Bank (2020) have analyzed the impact of trade restrictions and export bans on agricultural supply chains. They found that such measures, while initially intended to secure domestic food supplies, could exacerbate global food price volatility and disrupt agricultural trade flows.

2. Materials and Methods

2.1 Study Area

Ebonyi State, our study area is in the humid tropical agro-ecological zone of Nigeria, within longitudes 7°30′E to 8°30′E and latitudes 5°40′N to 6°45′N (Arochukwu et al., 2025). The state covers a land area of approximately 6,488 km². According to projections using a growth rate of 2.5%, Ebonyi State's population was estimated to be about 3,242,500 persons in 2022, based on data from the National Population Commission (National Population Commission, 2022). The climate of Ebonyi state is that of humid tropical climatic region, with two seasons which are rainy season between April and October and dry season which is felt between November and March. It is located at an elevation of 113 meters above sea level. Mean annual temperature stands at 28^0C with average rainfall of 1200mm - 2500mm.

2.2 Sampling techniques and questionnaire development

In this study, cross-sectional data collected directly from the agricultural firms' owners and managers were used. Quantitative data were collected through structured surveys. The survey questionnaire was designed to capture information about changes in production levels, disruptions in transportation and distribution, price fluctuations, income losses, and market closures. A multi-stage sampling technique was used to select a representative sample from different regions within the state. In the first stage, stratified random sampling method was used to divide the study population into three strata based on Ebonyi State's agricultural zones: Ebonyi South, Ebonyi North and Ebonyi Central. In the second state, two Local Government Areas (LGAs) were selected from each agricultural zone to have total of six LGAs. In the next stage, a list of registered agripreneurs were obtained from the Trade and Commerce Department of the LGAs from where seventy-five (75) agripreneurs were randomly drawn from each LGA making a total of four hundred and fifty (450) respondents.

2.3 Data analysis

Descriptive statistics like frequencies and percentages as well as inferential statistics like seemingly unrelated regression (SUR) were employed in the data analyses.

2.3.1 The Seemingly Unrelated Regression (SUR)

The study considered the possibility of agripreneurs' survival after the COVID-19 pandemic. Net profit is a critical variable in firm survival analysis, defined as gross profit minus all operational and exit costs, where exit costs refer to the expenses associated with closing a business and leaving the market. For a firm to survive over a multi-year period, net profit must remain non-negative; persistent negative net profit typically leads to business failure and market exit. A positive net profit suggests growth potential, while zero net profit indicates the firm is merely breaking even. Thus, the technical requirement for long-term survival is that net profit should not fall below zero (Christopoulos et al., 2019; Thompson & George, 1984; Delmar et al., 2013). The SUR was employed in analyzing the determinants of survival (net profit) of the agripreneurs in Ebonyi state for the periods after the peak of the crisis, particularly in 2023.

The SUR system of equations presented by Zellner (1962) consists of several M linear regression equations where M≥2. Each regression equation gives us a specific causal relationship or a statistical regression relationship between the endogenous variable and one or more exogenous variables. The number of equations in the system model is equal to the number of endogenous variables. The system of equations comprising M of the regression equations is as follows:

$y_i = X_i\beta_i + \mu_i$ … (1)

Where, i =1…, m; vector of y_i (Tx1) endogenous variable observations, $y_i = (y_i, \ldots Y_{ti})$. X = set of explanatory variables. It can be noticed that each equation in the SUR model is a linear regression model, and it seems unrelated at first sight, but they are related through random error terms. For a more multivariate approach, the equation (1) can be explicitly specified for three categories of agripreneurs (crop and livestock producers, crop and livestock processors and distributors of agricultural products) in form, following AL-Bermani and Kadhim (2002):

$$Y_{1t} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \mu_1 \ldots (2)$$

$$Y_{2t} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \mu_1 \ldots (3)$$

$$Y_{3t} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \mu_1 \ldots (4)$$

Where, Y_{1t}, Y_{2t} and Y_{3t} are the average net profits of the crop and livestock producers, crop and livestock processors and distributors of agricultural products respectively for 3 years (2021-2023 in Naira); μ_1, μ_2, μ_3 = error terms

X_1 = Age of the agribusiness (years)

X_2 = Size of the agribusiness (Number of employees)

X_3 = Agribusiness location (Dummy: urban = 1; otherwise = 0)

X_4 = Hazard (Dummy: past occurrence of shock = 1; otherwise = 0)

X_5 = Diversity of product mix (Dummy: Yes = 1; no = 0)

X_6 = Capital (Naira)

X_7 = Access to credit (Dummy: Yes = 1; No = 0)

X_8 = Beneficiary of social net benefits (Dummy: Yes = 1; No = 0)

X_9 = Operation risk (ratio of standard deviation to mean of net profit)

The SUR data were therefore analyzed by jointly estimating multiple related equations using the Feasible Generalized Least Squares method. Initial OLS estimates were used to derive the cross-equation error covariance matrix, after which the system was estimated simultaneously to account for contemporaneous correlation among error terms and improve efficiency.

3. Results and Discussion

3.1 Categories of the agricultural supply chain actors

Table 1 shows the distribution of various categories of agripreneurs' involvement in supply chain of agricultural products.

Table 1: Categories of the agricultural supply chain actors

Categories	Freq.	Percent
Crop and livestock farming	105	23
Crop and livestock processing	200	44
Distributors (wholesaler-retailer)	120	27
Consumer	25	6
Total	**450**	**100**

The result shows that four (4) major categories of agricultural supply chain actors were sampled in the study. Crop/livestock processors were in the majority (44%), followed by distributors (27%), crop/livestock farmers (23%) and consumers (6%). Agricultural production and farming represent the first stages of the supply chain (SC). In this first stage, agricultural food raw materials are produced, derived from the activities of the agriculture – crop, forestry, livestock and fishery sectors (Stone and Rahimifard, 2018).

The processing stage distinguishes the agricultural food sector and consists of all processing steps of raw materials and semi-finished products, up to the packaging stage. The stages are different for each food product. At this stage, agricultural food raw materials are processed through one or more value-added processes (Hobbs and Young, 2000; Cucagna and Goldsmith, 2018).

Products can be delivered to consumers in two ways: through retail or food service. The retail trade is principally handled by large-scale retail enterprises. Wholesalers provide the link between the production and distribution stages. Wholesalers purchase agricultural or industrial products for resale to retail entities (Olhager et al., 2015). Distribution/logistics encompasses organizational, strategic, and managerial processes within the SC. Its task is to manage physical, and information flows from the production stage to the consumption stage, optimizing activities and responding efficiently to customer demands. The activities performed range from the procurement of raw materials to the preparation of orders and transportation through the distribution network. At different stages, logistics are composed of different specificities due to the nature of the products, which can be fresh, dry, or frozen; the complexity of the production; the internationalization and geographical distance of markets; and the development of numerous sales channels (Sachan and Datta, 2005).

3.2 COVID-19 induced supply chain disruptions in the agricultural sector

The agripreneurs were asked how the COVID-19 pandemic affected their involvement in the agricultural supply chain in Ebonyi State. Their responses are presented in Table 2.

Table 2. Extent of COVID-19 induced agricultural sector supply chain disruption

Extent of disruptions	**Freq.**	**Percent**
Severely	230	51
Moderately	110	24

Slightly	80	18
No disruption	30	7
Total	**450**	**100**

The result shows that majority (51%) of the respondents stated that the pandemic severely disrupted their supply chain activities. About 24% and 18% reported moderate and slight disruptions respectively while 7% said to have had no disruption. In other words, the pandemic negatively affected every facet of life and supply chains were radically disrupted as well as currency markets thereby witnessing supply and demand shock.

COVID-19 agricultural sector supply chain challenges

The COVID-19 pandemic was a notable black swan event that had a lasting impact on society, the economy, and public health. The agripreneurs were therefore asked to describe the specific disruptions or challenges they encountered during the COVID-19 pandemic in the agricultural supply chain. Their responses are presented in Table 3.

Table 3. COVID-19 agricultural sector supply chain challenges in Ebonyi state

Specific challenges	**Frequency****	**Percentage**
Disruption in transportation and logistics	440	98
Shortage of agricultural labor	350	78
Closure of markets or retail outlets	275	61
Supply chain bottlenecks (e.g., delays in procurement/distribution)	390	87
Price fluctuations (e.g., sharp price increases or decreases)	445	99
Loss of perishable goods (e.g., fruits and vegetables)	340	76
Reduced access to agricultural inputs (e.g., seeds, fertilizers)	225	50
Challenges in accessing financial support or credit	280	62
Government regulations or restrictions impacting agriculture	200	44
Increased production costs	300	67
Lack of access to technology for remote work or sales	150	33
Health and safety concerns for workers	390	87
Difficulty in adapting to new safety protocols	335	74

** = multiple responses

The result shows that price fluctuations (99%), and disruption in transportation and logistics (98%) were the major challenges and disruptions faced by agricultural supply chain actors during the COVID-19 global lockdown. There were issues of supply chain bottlenecks (87%) and workers' health and safety concerns (87%) as well as shortage of agricultural labour (78%), loss of perishable goods (76%), difficulty in adapting to new safety protocols (74%).

Fluctuation in prices was a major agricultural products supply chain disruption in Ebonyi state. Agricultural product prices first rose because of COVID-19's effects, since there was less supply and more demand because of panic buying. Later, tightening limitations and a decline in consumer spending power led to a major reduction in both demand and supply, which in turn led to lower product prices. The propagation of these impacts has thus had knock-on effects along SCs, the so-called 'Ripple Effect' (Weersink et al., 2021), causing shortages for some products and price increases at the distribution stage. According to Coluccia et al. (2021), Weersink et al. (2020), Liu and Ren (2024)

and Grinberga-Zalite et al. (2021), price increases caused by limited access to raw materials understood as labor and packaging materials have also caused problems for consumers, who have been in some cases forced to give up quality food in favor of cheaper food.

Generally, most agricultural products are transported from production sites to wholesale distributors, retailers or even consumers. Movement of goods is usually affected almost by total cancellation/high restriction of movements (Deconinck et al., 2021). Such logistical disruptions and the application of movement restrictions limited access to some major crops and livestock markets (Ravera et al., 2021), especially, since road transport is the main mode of transport for agricultural food products in the state (Hatab et al., 2020).

Due to the restricted movement imposition, the agricultural products actors battled with so many products without adequate access to markets. The poor storage system compounded the challenge, forcing the supply chain actors to sale their products at lower prices or donated to charities (Coopmans et al., 2021). Increased inventories due to declines in demand for some livestock products, fruits, vegetables and other fresh and highly perishable products led to higher costs for cold storage with reduced margins, which were already significantly impacted (Lopez-Ridaura et al., 2021; Wang et al., 2020).

On the distribution side, the agricultural entrepreneurs reported cases of bureaucracies and bottlenecks such as delayed distribution due to the need to adhere to all COVID-19 protocols. According to (Weersink et al., 2021), this led to a change in demand for certain types of agricultural products, especially, the more perishable ones (those with very short shelf-lives). These adjustments, having repercussions on all other stages of the SCs, have been major short-term challenges for the agricultural products' SCs (Hobbs, 2021; Coopmans et al., 2021).

3.3 Adaptations and strategies employed by different actors within the agricultural supply chain to mitigate the impact of disruptions caused by the pandemic

The respondents were asked if they adopted specific strategies to cope with the disruptions caused by the COVID-19 pandemic in the agricultural supply chain and their responses are presented in Tables 4 and 5.

3.3.1 Adoption of mitigation strategies

The distribution of the agricultural entrepreneurs by their decision to adopt mitigation strategies to COVID-19 disruptions is presented in Table 4.

Table 4: Distribution of respondents based on adoption of mitigation strategies

Adopted mitigation strategies	**Frequency**	**Percent**
Yes	375	83
No	75	17
Total	**450**	**100**

The result showed that a great majority (83%) of the supply chain actors utilized COVID-19 disruptions mitigation strategies while 17% did not adopt mitigation strategies.

3.3.1 Adopted mitigation strategies

COVID-19 related market disruptions have reduced incomes for many SC actors in Ebonyi state, significantly eroding households' purchasing power and forcing consumers to replace certain products' intake with cheaper alternatives. The distribution of the agripreneurs by their various adopted mitigation strategies to COVID-19 disruptions is presented in Table 5.

Table 5: Distribution of respondents based on adopted mitigation strategies

Adopted mitigation strategies	Frequency**	Percentage
Diversifying product offerings to meet changing demand	305	81
Implementing new safety protocols and hygiene measures for workers	290	77
Expanding online sales and e-commerce channels	295	79
Collaborating with other stakeholders in the supply chain	305	81
Finding alternative transportation and logistics solutions	375	100
Exploring new markets or customer segments	270	72
Investing in technology for remote work or sales	290	77
Stockpiling essential agricultural inputs	250	67
Seeking financial support or grants for business continuity	300	80
Reducing operational costs through efficiency measures	325	87
Adapting production processes to reduce labor requirements	330	88
Participating in government relief programs	270	72

** = multiple responses

Finding alternative transportation and logistics solutions (100%), adapting production processes to reduce labor requirements (88%), reducing operational costs through efficiency measures (87%), diversifying product offerings to meet changing demand (81%), Seeking financial support or grants for business continuity(80%), expanding online sales and e-commerce channels (79%), investing in technology for remote work or sales (77%) among others were the mitigation practices employed by the SC actors in curbing the disruptive impacts of COVID-19 pandemic.

As the food consumption of end-customers changed, different products experienced vertical drops in demand. One of the main measures consisted of reducing the variety of products to focus exclusively on the most popular ones (Deconinck et al., 2021). Some actors experiencing an interruption of supply channels reacted through self-production or stockpiled inventories for the short term since they were mainly perishables. Other solutions involved the search for alternative supplies, mostly local (Deconinck et al., 2021).

Locally based systems were advantaged in finding new sales channels and end consumers because of strong personal relationships and trust. In contrast, other systems, due to a lack of skills and relationships, failed to develop such relationships and thus lost customers and revenue (Hobbs 2020b). Food processors and handlers responded by implementing or strengthening takeaway and home delivery services.

A widely applied measure by individual country governments was to provide funds and subsidies. Another central measure was to offer the possibility of purchasing unsold products at a reduced price for distribution to organizations that support people most in need (Lopez-Riduana et al., 2021). For instance, government responses in Nigeria during the COVID-19 pandemic included the provision of soft loans, subsidies, and financial assistance through special programs and interventions to support both agricultural products employees and business owners affected by the crisis. These measures aimed to alleviate financial difficulties and sustain agricultural activities, with

recommendations for organized provision of loans and grants to address sector-specific challenges (Ilesanmi et al., 2021; Ejiogu et al., 2020; Agbugba et al., 2022).

İn the study area, some producers and distributors used digital solutions to explore or strengthen alternative sales channels when traditional ones were closed. In response to the effects of the pandemic, alternative sales and delivery methods were explored, such as e-commerce and online delivery (Ravera et al., 2021; Deconinck et al., 2021). The ability to sell food through online platforms helped small producers in shortening the distance to the final consumer (Weersink et al., 2021). However, not all small businesses were able to take advantage of this opportunity as only a few urban SC distributors could manage the associated logistics. Since these SC actors were majorly small scaled, they were unprepared (Hobbs, 2020a), with a risk of further losses in the future (Hatab et al., 2021). Urban consumers explored digital platforms to aggregate a large number of producers and connect with them. This gave rise to online food markets while prospective consumers could place orders and have their products delivered to them (Lopez-Riduana et al., 2021).

A major mitigation strategy was the diversification of markets, customers, and sales channels (Lopez-Riduana et al., 2021). Diversification can be seen as a good measure - more easily applicable before a shock event to increase resilience and better cope with adverse events, even at the expense of the also-attainable economies of scale and consequent economic gains (Bisoffi et al., 2021). In Ebonyi state, like other parts of Nigeria and Africa, supply chain diversification during the COVID-19 crisis was limited, especially for highly perishable products facing significant transport constraints (Nordhagen et al., 2021). According to Cheraffi et al. (2022) and Ashiru et al. (2022), diversification was therefore more feasible for products not requiring specialized atmospheric, environmental, or rapid transport conditions. Their findings further highlighted that only a few supply chains were able to anticipate disruptions by diversifying, with most efforts focused on less perishable goods due to the complexity and resource demands of handling perishable products under pandemic restrictions. From the foregoing, building resilience to future shocks have become inevitable (Lawal, 2022).

3.4 Socio-Economic implications of the pandemic-related disruptions on agripreneurs' income, food security and overall well-being in Ebonyi state

The respondents were requested to express how the COVID-19 disruptions affected their incomes, food security and overall well-being.

3.4.1 Economic implications of COVID-19 pandemic on incomes of agripreneurs

The respondents' responses on how the disruptions caused by the pandemic affected their income in relation to agricultural entrepreneurship are presented in Table 6.

Table 6. Economic implications of COVID-19 pandemic on incomes of agripreneurs

Extent of impact on income	Freq.	Percent
Significant increase	100	22
Significant decrease	198	44
Moderate increase	55	12
Moderate decrease	80	18
No change	17	4
Total	**450**	**100**

A significant portion of agripreneurs experienced income changes during the COVID-19 pandemic, with 44% reporting a significant decrease, 22% a significant increase, 18% a moderate decrease, and 12% a moderate increase. Overall, 62% witnessed a decrease in income, 34% saw an increase, and 4% reported no change. Empirical evidence suggest that lower incomes and uncertainty typically lead to reduced consumer spending and lower demand, resulting in shifts in consumption habits and consumer behavior, such as restricted access to fresh and perishable food (Borsellino et al., 2020; Martinez-Azua et al., 2021; Gu & Wang, 2020; Cranfield, 2020; Valaskova et al., 2021). The studies further confirmed that the pandemic caused both negative and positive financial impacts for agricultural food businesses, with changes in consumer behavior driven by economic downturns, uncertainty, and altered purchasing power.

3.4.2 Economic implications of COVID-19 pandemic on food security of agripreneurs

The respondents were asked to discuss how the pandemic have contributed to changes in their food security conditions. The results are presented in Table 7.

Table 7. Economic implications of COVID-19 pandemic on food security of agripreneurs

Extent of impact on income	**Frequency**	**Percent**
Increased food insecurity (difficulty in accessing sufficient and nutritious food)	150	33
No significant change in food security	10	2
Improved food security (e.g., better access to food sources)	65	14
Relying on alternative food sources or diets	80	18
Receiving food aid or assistance	95	21
Increased reliance on home gardening or farming	50	11
Total	**450**	**100**

The respondents stated that the COVID-19 pandemic increased food insecurity (33%); some of them relied on food aids (21%), relied on alternative food sources or diets (18%) while 14% are of the opinion that food security was improved during the pandemic.

The coronavirus pandemic (COVID-19) is considered as one of the major food-security risks factors in recent times as it affected global economies, food production and food supply activities dramatically (Althumiri et al., 2021; Barmann et al., 2021; Moretto et al., 2021). COVID-19 has directly influenced food supply chains and agriculture – in the areas of food supply and food demand. These two perspectives directly affect food security; during the start of the COVID-19 pandemic, panic buying left empty shelves at supermarkets and stores because of sudden changes in demand (Barmann et al., 2021; Alsuwailem et al., 2022). Interestingly, there was an increase in the demand and consumption of food, as people have tended to stock them up during quarantines and lockdowns (Montenegro & Young, 2020).

In addition, it was reported that during the COVID-19 pandemic, more than 1 billion people suffered from nutritional deficiencies, which is an increasing global issue due to food insecurity, and, therefore, these problems can have detrimental effects on public health, including diabetes, heart disease, depression, etc. As a result, there are now more people who are food insecure than there were a few years ago (Abu Nahleh et al., 2023). In 2019, 8.9% of the world's population (about 690 million people) suffered from malnutrition, and this figure has grown due to pandemic-related disruptions (Headey et al., 2020; Smith & Wesselbaum, 2020; Hassen & Bilali, 2024). Food prices have

also surged since February 2020, with increases exceeding 10% in many developing countries, including Nigeria, further exacerbating food access and nutrition challenges (Laborde et al., 2021). These disruptions have had detrimental effects on public health, as food insecurity is closely linked to a higher prevalence of chronic diseases and poor mental health outcomes (Leddy et al., 2020).

3.4.3 Economic implications of COVID-19 pandemic on overall wellbeing of agricultural entrepreneurs

The respondents were asked to discuss how they perceived their overall well-being as impacted by the pandemic-related disruptions in the agricultural supply chain. The result is presented in Table 8.

Table 8. Economic implications of COVID-19 pandemic on wellbeing of agricultural entrepreneurs

Extent of impact on overall wellbeing	**Frequency**	**Percent**
Significantly worsened well-being	90	20
Moderately worsened well-being	105	23
Slightly worsened well-being	75	17
No significant change in well-being	60	13
Improved well-being due to specific adaptations or support	120	27
Total	**450**	**100**

The result revealed that the COVID-19 pandemic had a mixed impact on agripreneurs' well-being. The majority experienced worsened well-being (around 60%), while 27% reported improvements due to specific adaptations, and 13% saw no significant change in their well-being. These outcomes reflect both the negative financial and operational challenges as well as the positive effects of adaptive strategies such as increased use of technology and new marketing approaches (Martinez-Azua et al., 2021; Alam et al., 2023; Sama-Berrocal & Martinez-Azua, 2022).

3.5 Determinants of agricultural firms' survival after COVID-19 crises

To examine the factors responsible for the survival and recovery of firms after the pandemic, the Seemingly unrelated regression (SUR) model was employed. The results show that size of production (measured by number of employees) was positive for producers and marketers at 5% and 10% respectively; location of the agribusiness was positive for producers, processors and marketers at 5%, 5% and 1% levels of significance respectively. Previous experience of hazard was positive at 5%, 1% and 10% levels of significance for producers, processors and marketers respectively; product diversity mix was positive for producers at 1% level of significance; capital was positive for the three categories at 10%, 1% and 5% significant levels respectively; beneficiary of social nets benefits was positive at 10% and 5% for processors and marketers respectively while operation risk was negative at 5% for marketers only. The result is presented in Table 9.

Table 9: SUR estimates of the determinants of agribusiness firms' post COVID-19 crises survival

Variables	Crop and livestock producers			Crop and livestock processors			Agricultural products marketers/distributors		
	Coeff.	Std. Error	Z	Coeff.	Std. Error	Z	Coeff.	Std. Error	Z
Intercept	1763276	908767.8	1.94	876014.7	925611.3	0.95	609383	925500.5	0.66
Age of the agribusiness (years)	-31059.54	72220.4	-0.43	-29150.63	77298.55	-0.38	-23680.11	74895.1	-0.32
Firm size (number of employees)	284628.8	115661.2	2.46**	-54612.72	108369.7	-0.50	158234.2	86829.7	1.82*
Agribusiness location	388767.8	189298	2.05**	450382.5	205749	2.19**	575927.1	185636.8	3.10***
Previous hazard occurrence	185139.1	86007.7	2.15**	223859.3	56906.8	3.93***	237815.4	141745.4	1.68*
Diversity of product mix	203334.2	60610.6	3.35***	98867.56	164631.7	0.60	79939.7	171891.1	0.47
Capital (Naira)	1.256098	.6531699	1.92*	.5413745	.1931049	2.80**	1.6794	.6674777	2.52**
Access to credit	-33512.37	149521.9	-0.22	-83481.15	142217.1	-0.59	50878.69	142266.9	0.36
Beneficiary of social net benefits	61663.95	222348.9	0.28	247002.6	136751.7	1.81*	443531.4	224130.3	1.98*
Operation risk	40597.85	179900.2	0.23	109905.1	186931.2	0.59	-258350.4	169760.8	-2.35**
Model R^2	0.232			0.186			0.380		
Root MSE	7.356			7.537			6.719		

***, **, and * = 1%, 5% and 10% levels of significance respectively.

Findings showed that firm size and recovery were positively related implying that larger agribusiness firms recovered better and faster than smaller firms. Agribusiness firms with more employees typically have larger capital bases, higher labour productivity, and broader organizational resources than smaller firms, reflecting greater compensation of employees, gross operating surplus, and capital intensity in large enterprises. Relevant literature like Pedauga et al. (2021), Ambrogio et al. (2022) opined that such resource advantages helped many larger agribusiness firms better absorb shocks from input shortages, temporary shutdowns, and demand/supply disturbances, including supply-chain breaks and global value chain disruptions, thereby supporting resilience and survival relative to more constrained small firms. In addition, Firm size is closely linked to technology adoption and digital innovation, with larger firms generally having greater resources, readiness, and incentives to integrate advanced digital technologies than micro and small firms. Larger firms are more likely to adopt digital platforms, advanced manufacturing and supply-chain technologies, supported by higher organizational readiness, lower security concerns, and more developed digital capabilities (Shahzad et al., 2024). According to Mishrif and Khan (2023), Cui et al. (2022) and Ambrogio et al. (2022), adoption of these technologies enhanced supply-chain coordination and integration, reduced coordination and transaction costs, and supported information processing across suppliers and customers, thereby improving operational efficiency.

The positive coefficient of location indicates that agribusiness firms situated in urban areas were generally better positioned to survive and recover following the COVID-19 crisis. Dixon et al. (2021) and Weersink et al. (2020) all asserted that urban locations provided advantages such as improved access to markets, supply chains, and support services, which helped firms adapt more quickly to disruptions caused by the pandemic. Findings further revealed urban-based firms benefited from stronger infrastructure, diversified market channels, and greater policy support, all of which contributed to their resilience and recovery compared to their rural counterparts (Alam et al., 2023).

Findings also showed that the coefficient of hazard experience was positively signed, implying that agribusiness firms with previous experiences of hazards survived and recovered faster than those without any experience. This aligns with research demonstrating that prior experience and learning from past disruptions can significantly enhance a firm's ability to adapt, reduce the hazard rate, and increase the likelihood of survival in the face of new challenges (Roner and Tomasi, 2024). Firms that have navigated previous hazards develop resilience and adaptive strategies, which contribute to faster recovery and greater long-term sustainability compared to firms lacking such experience.

The positive diversification coefficient for crop and livestock producers indicates that producing a variety of crops and livestock helped buffer the impacts of COVID-19 shocks, enabling these agripreneurs to recover more quickly after the crisis. Studies showed that diversification strategies such as integrating different crops, livestock, and aquaculture, or expanding product and marketing channels stabilized income and food availability during the pandemic, making producers more resilient to disruptions (Wang et al., 2024; Benedek et al., 2021; Marsden et al., 2023). Diversified farms were better able to adapt to changing market conditions and supply chain interruptions, and this resilience was observed across different contexts, including small-scale and agricultural tourism operations (Mastronardi et al., 2021; Brune et al., 2023).

Capital was positively signed for all the agripreneurs, suggesting that firms with more capital survived and recovered faster from the COVID-19 crisis than agripreneurs with limited capital. Empirical evidence shows that agribusinesses with better access to finance were less likely to experience declines in sales or exit the market and were better able to withstand pandemic-induced shocks (Özşuca, 2024; Liu et al., 2024). Higher levels of working capital and a stronger net working capital ratio were associated with improved financial performance during the pandemic, highlighting the importance of liquidity and capital reserves for resilience and conversely, agribusinesses facing credit constraints or limited capital were more likely to suffer from cash flow problems, overdue financial obligations, and operational disruptions, making recovery more difficult (Zharare and Mashingaidze, 2020).

Access to social net benefits during the COVID-19 crisis was positively related to survival and recovery from the pandemic, implying that agripreneurs who had access to social net benefits survived and recovered faster than those who had no access. Empirical evidence show that government social assistance programs, such as direct cash transfers and social protection schemes, played a crucial role in alleviating credit constraints, supporting agricultural investments, and protecting food security for vulnerable households and agribusinesses during the crisis (Varshney et al., 2021; Abay et al., 2020). Households and agripreneurs benefiting from these programs were less likely to reduce expenditures on essential inputs, health, and education, and experienced smaller increases in food insecurity compared to those without such support.

Operation risk was negatively related to survival for marketers, implying that as operational risk increased, survival and recovery after COVID-19 was compromised. Research shows that higher operational risks such as increased costs, market inaccessibility, supply chain disruptions, and price fluctuations significantly reduced the performance and resilience of agribusinesses during the pandemic, leading to reduced revenues, increased spoilage, and greater vulnerability to business closure (Nganu et al., 2024; Hatab et al., 2023; Ali & Govindan, 2021). Firms with limited resources and inadequate risk management strategies were particularly affected, as they struggled to adapt to the rapidly changing environment and were less able to recover from disruptions (Hatab et al., 2020).

5. Conclusions

The COVID-19 pandemic has triggered unprecedented disruptions in global supply chains across various sectors, with agriculture being particularly vulnerable to its cascading effects. This study was therefore conducted to examine the impact of COVID-19 pandemic on the supply chain activities of agricultural products in Ebonyi state, Nigeria. The result shows that four (4) major categories of agricultural supply chain actors were sampled in the study. Crop/livestock processors were in the majority (44%), followed by marketers/distributors (27%), crop/livestock producers (23%) and consumers (6%). The result shows that majority (51%) of the respondents stated that the pandemic severely disrupted their supply chain activities. Generally, it could be inferred that a majority (57%) witnessed a decrease in their incomes due to the pandemic disruption in supply chain. The result revealed that generally, majority of agricultural entrepreneurs (60%) experienced one form or the other of a worsened well-being. To mitigate these COVID-19 inflicted disruptions, the SC actors resorted to finding alternative transportation and logistics solutions, adapting production processes to reduce labor requirements, reducing operational costs through efficiency measures, diversifying product offerings to meet changing demand, seeking financial support or

grants for business continuity and expanding online sales and e-commerce channels. The estimates of the Seemingly unrelated regression (SUR) model show that size of production (measured by number of employees), location of the agribusiness, previous experience of hazard, product diversity mix, capital, social net benefits and operation risk were responsible for the recovery and survival of agribusiness firms after the COVID-19 pandemic.

Agribusiness firms must manage operational risks to enhance the survival and recovery prospects of agribusinesses, especially during crises like COVID-19. Government must provide robust social safety nets to enhance the resilience and recovery of agribusinesses during systemic shocks. There is need for multi-layered diversification, including product and income stream diversification to build resilience against shocks. Agribusiness firms should strategically adopt and integrate appropriate digital technologies to enhance operational flexibility, reduce transaction costs, improve responsiveness to future disruptions and strengthen the post-COVID-19 recovery and long-term resilience of the agricultural sector.

Limitation (endogeneity)

This study may be subject to potential endogeneity arising from reverse causality, as variables such as access to capital and technology adoption may both influence and be influenced by agribusiness survival during COVID-19. Consequently, the estimated relationships should be interpreted as associative rather than strictly causal. Future research could therefore extend this analysis using panel data or instrumental variable techniques.

Author Contributions: Conceptualization – D.C. Nwaogu and M.O. Godwin; Methodology, data curation and analyses – D.C. Nwaogu; writing (original draft preparation, review and editing) – D.C. Nwaogu, M.O. Godwin, B.C. Nwaogu; Supervision and project administration – D.C. Nwaogu. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: The authors are grateful to all who made this research a success.

Conflicts of Interest: The authors declare no conflict of interest.

Data availability statement: Data would be made available on reasonable request.

6. References

1. Abay K, Berhane G, Hoddinott J, Tafere K (2020): COVID-19 and Food Security in Ethiopia: Do Social Protection Programs Protect?. *Economic Development and Cultural Change* 71, 373 - 402. https://doi.org/10.1086/715831.
2. Abu Nahleh Y, Al-Ali B, Al-Ali H, Alzarooni S, Almulla S, Alteneiji F (2023): The Impact of COVID-19 on Supply Chain in UAE Food Sector. Sustainability 15(11), 8859.
3. Aday S, Aday MS (2020): Impact of COVID-19 on the food supply chain. Food Quality and Safety 4(4), 167-180.
4. Agbugba I, Agbagwa S, Anumudu C, Ekwebelem O, Al-Sharify Z, Isaac-Bamgboye F, Onyeaka H (2022): The evolving state of food security in Nigeria amidst the COVID-19 pandemic – A review. *Open Agriculture* 7, 899 - 909. https://doi.org/10.1515/opag-2022-0149.
5. Alam, G., Khatun, M., Sarker, M., Joshi, N., & Bhandari, H. (2023). Promoting agriculturalfood systems resilience through ICT in developing countries amid COVID-19. , 6. https://doi.org/10.3389/fsufs.2022.972667.
6. Al-Bermani FAHJ, Kadhim AH (2002): Error components and seemingly unrelated regression with application workable. Baghdad.
7. Aldianto L, Anggadwita G, Permatasari A, Mirzanti I, Williamson I (2021): Toward a Business Resilience Framework for Startups. *Sustainability*. https://doi.org/10.3390/su13063132.
8. Ali A, Mahfouz A, Arisha A (2017): Analysing supply chain resilience: integrating the constructs in a concept mapping framework via systematic literature review. *Supply Chain Management* 22, 16-39. https://doi.org/10.1108/scm-06-2016-0197.
9. Ali I, Govindan K (2021): Extenuating operational risks through digital transformation of agriculturalfood supply chains. *Production Planning & Control* 34, 1165 - 1177. https://doi.org/10.1080/09537287.2021.1988177.
10. Alsuwailem AA, Salem E, Saudagar AKJ, AlTameem A, AlKhathami M, Khan MB, Hasanat MHA (2022): Impacts of COVID-19 on the Food Supply Chain: A Case Study on Saudi Arabia. Sustainability, 14, 254.
11. Althumiri NA, Basyouni MH, Saeed F, Zamakhshary M, BinDhim NF (2021): Food Taste, Dietary Consumption, and Food Preference Perception of Changes Following Bariatric Surgery in the Saudi Population: A Cross-Sectional Study. Nutrients, 13(10), 3401. https://doi.org/10.3390/nu13103401
12. Ambrogio G, Filice L, Longo F, Padovano A (2025): Workforce and supply chain disruption as a digital and technological innovation opportunity for resilient manufacturing systems in the COVID-19 pandemic. *Computers & Industrial Engineering* 169, 108158. https://doi.org/10.1016/j.cie.2022.108158.
13. Anigbogu TU, Uzondu CS (2018): Determinants of Output Performance of Cooperative Farmers in Anambra State, Nigeria. Journal of Agriculture and Rural Development 1(1), 61-67.
14. Arochukwu A, Ike F, Adewoyin A, Eludoyin A (2025): Population changes and primary healthcare delivery in Ebonyi State, Nigeria. *Discover Health Systems* 4. https://doi.org/10.1007/s44250-025-00235-5.
15. Ashiru F, Nakpodia F, You J (2022): Adapting emerging digital communication technologies for resilience: evidence from Nigerian SMEs. *Annals of Operations Research* 1 - 29. https://doi.org/10.1007/s10479-022-05049-9.
16. Aven T (2016): Risk assessment and risk management: Review of recent advances on their foundation. *Eur. J. Oper. Res.* 253, 1-13. https://doi.org/10.1016/j.ejor.2015.12.023.

17. Barman A, Das R, De PK (2021): Impact of COVID-19 in food supply chain: Disruptions and recovery strategy. Current Research in Behavioral Sciences 2, 100017.
18. Benedek Z, Fertő I, Marreiros C, De Aguiar P, Pocol C, Čechura L, Põder A, Pääso P, Bakucs Z (2021): Farm diversification as a potential success factor for small-scale farmers constrained by COVID-related lockdown. Contributions from a survey conducted in four European countries during the first wave of COVID-19. *PLoS ONE* 16. https://doi.org/10.1371/journal.pone.0251715.
19. Bisoffi S, Ahrné L, Aschemann-Witzel J, Báldi A, Cuhls K, DeClerck F, Brunori G (2021): COVID-19 and sustainable food systems: what should we learn before the next emergency. Frontiers in Sustainable Food Systems 5, 650987.
20. Bitzer V, Kruijssen F, Mugisha J, Waswa L, Aliso J, Nakazzi B (2024): Vulnerability and resilience among farmers and market actors in local agri-food value chains in the face of COVID-19 disruptions: findings from Uganda and Kenya. *Food Security* 16, 185 - 200. https://doi.org/10.1007/s12571-023-01414-z.
21. Borsellino V, Kaliji S, Schimmenti E (2020): COVID-19 Drives Consumer Behaviour and Agro-Food Markets towards Healthier and More Sustainable Patterns. *Sustainability*. https://doi.org/10.3390/su12208366.
22. Brune S, Knollenberg W, Vilá O (2023): Agritourism resilience during the COVID-19 crisis. *Annals of Tourism Research* 99, 103538 - 103538. https://doi.org/10.1016/j.annals.2023.103538.
23. Cherrafi A, Chiarini A, Belhadi A, Baz J, Benabdellah A (2022): Digital technologies and circular economy practices: vital enablers to support sustainable and resilient supply chain management in the post-COVID-19 era. *The TQM Journal*. https://doi.org/10.1108/tqm-12-2021-0374.
24. Chidiebere-Mark N, Ohajianya D, Obasi P, Onyeagocha S (2019): Profitability of rice production in different production systems in Ebonyi State, Nigeria. *Open Agriculture* 4, 237 - 246. https://doi.org/10.1515/opag-2019-0022.
25. Christopoulos A, Dokas I, Kalantonis P, Koukkou T (2019): Investigation of financial distress with a dynamic logit based on the linkage between liquidity and profitability status of listed firms. *Journal of the Operational Research Society* 70, 1817 - 1829. https://doi.org/10.1080/01605682.2018.1460017.
26. Coluccia B, Agnusdei G, Miglietta P, De Leo F (2021): Effects of COVID-19 on the Italian agriculturalfood supply and value chains. *Food Control* 123, 107839 - 107839. https://doi.org/10.1016/j.foodcont.2020.107839.
27. Coopmans I, Bijttebier J, Marchand F, Mathijs E, Messely L, Rogge E, Wauters E (2021): COVID-19 impacts on Flemish food supply chains and lessons for agricultural food system resilience. Agricultural Systems 190, 103136.
28. Cranfield J (2020): Framing consumer food demand responses in a viral pandemic. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie*. https://doi.org/10.1111/cjag.12234.
29. Cucagna ME, Goldsmith PD (2018): Maria Emilia Cucagna and Peter D. Goldsmith. International Food and Agribusiness Management Review 21(3), 293-316.
30. Cui L, Wu H, Wu L, Kumar A, Tan K (2022): Investigating the relationship between digital technologies, supply chain integration and firm resilience in the context of COVID-19. *Annals of Operations Research* 1 - 29. https://doi.org/10.1007/s10479-022-04735-y.
31. Dapilah F, Nielsen J, Friis C (2020): The role of social networks in building adaptive capacity and resilience to climate change: a case study from northern Ghana. *Climate and Development* 12, 42 - 56. https://doi.org/10.1080/17565529.2019.1596063.

32. DeConinck D, Frissen T, Matthijs K, d'Haenens L, Lits G, Champagne-Poirier O, Généreux M (2021): Beliefs in conspiracy theories and misinformation about COVID-19: Comparative perspectives on the role of anxiety, depression and exposure to and trust in information sources. Frontiers in psychology, 12, 646394.
33. Deconinck K, Avery E, Jackson L (2020): Food Supply Chains and Covid-19: Impacts and Policy Lessons. *EuroChoices* 19, 34 - 39. https://doi.org/10.1111/1746-692x.12297.
34. Delmar F, McKelvie A, Wennberg K (2013): Untangling the Relationships Among Growth, Profitability and Survival in New Firms. *ERPN: Firm Production (Sub-Topic)*. https://doi.org/10.1016/J.TECHNOVATION.2013.02.003.
35. Dixon J, Weerahewa J, Hellin J, Rola-Rubzen M, Huang J, Kumar S, et al (2021): Response and resilience of Asian agrifood systems to COVID-19: An assessment across twenty-five countries and four regional farming and food systems. *Agricultural Systems*, 193, 103168 - 103168. https://doi.org/10.1016/j.agsy.2021.103168.
36. Ejiogu A, Okechukwu O, Ejiogu C (2020): Nigerian budgetary response to the COVID-19 pandemic and its shrinking fiscal space: financial sustainability, employment, social inequality and business implications. *Journal of Public Budgeting, Accounting & Financial Management*. https://doi.org/10.1108/JPBAFM-07-2020-0101.
37. Espitia A, Rocha N, Ruta M (2020): Covid-19 and food protectionism: the impact of the pandemic and export restrictions on world food markets. World Bank Policy Research Working Paper, (9253).
38. FAO (2020): The State of Agricultural Commodity Markets 2020. Agricultural markets and sustainable development: Global value chains, smallholder farmers and digital innovations. Rome, FAO. https://doi.org/10.4060/cb0665en
39. Glauber J, Laborde, DD, Martin W, Vos R (2020): COVID-19: Trade restrictions are worst possible response to safeguard food security. IFPRI book chapters, 66-68.
40. Grinberga-Zalite G, Pilvere I, Muska A, Kruzmetra Z (2021): Resilience of meat supply chains during and after COVID-19 crisis. Emerg Sci J. 5(1), 57-66.
41. Gu H, Wang C (2020): Impacts of the COVID-19 pandemic on vegetable production and countermeasures from an agricultural insurance perspective. *Journal of Integrative Agriculture* 19, 2866-2876. https://doi.org/10.1016/s2095-3119(20)63429-3.
42. Hani M (2020): COVID-19 and smallholder producers' access to markets. . https://doi.org/10.4060/ca8657en.
43. Hassen T, Bilali H (2024): Three years into the pandemic: Insights of the COVID-19 impacts on food security and nutrition in low and middle-income countries. *Heliyon* 10. https://doi.org/10.1016/j.heliyon.2024.e28946.
44. Hatab AA, Lagerkvist J, Esmat A (2020): Risk perception and determinants in small- and medium-sized agriculturalfood enterprises amidst the COVID-19 pandemic: Evidence from Egypt. Agribusiness 37(1). 187-212. https://doi.org/10.1002/agr.21676
45. Hatab A, Owusu-Sekyere E, Esmat A, Lagerkvist C (2023): In the midst of the COVID-19 pandemic: Perceived risks, management strategies and emerging opportunities for small and medium agriculturalfood enterprises in a developing country. *International Journal of Disaster Risk Reduction*. https://doi.org/10.1016/j.ijdrr.2023.104045.

46. Headey D, Heidkamp R, Osendarp S, Ruel M, Scott N, Black R, Shekar M, Bouis H, Flory A, Haddad L, Walker N (2020): Impacts of COVID-19 on childhood malnutrition and nutrition-related mortality. *Lancet (London, England)* 396, 519 - 521. https://doi.org/10.1016/S0140-6736(20)31647-0.
47. Hobbs JE (2021): Food supply chain resilience and the COVID-19 pandemic: What have we learned? Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie 69(2), 189-196.
48. Hobbs JE, Young LM (2000): Closer vertical co-ordination in agri-food supply chains: a conceptual framework and some preliminary evidence. Supply Chain Management: An International Journal 5(3), 131-143.
49. Hobbs JE (2020a): Food supply chains during the COVID-19 pandemic. Canadian Journal of Agricultural Economics/Revue Canadienned'agroeconomie 68(2), 171–176.
50. Hobbs JE (2020b). Food supply chains during the COVID-19 pandemic. Canadian Journal of Agricultural Economics, 68(2), 171–176.
51. Husni F, Suwarto F, Hariandja E, Tan J (2025): Thriving Through Adversity: A Survival Learning Framework for Entrepreneurial Transformation During the COVID-19 Crisis in Indonesia. *SAGE Open* 15. https://doi.org/10.1177/21582440251370428.
52. Ilesanmi F, Ilesanmi O, Afolabi A (2021): The effects of the COVID-19 pandemic on food losses in the agricultural value chains in Africa: The Nigerian case study. *Public Health in Practice* 2 https://doi.org/10.1016/j.puhip.2021.100087.
53. Ivanov D (2023): Two views of supply chain resilience. *International Journal of Production Research* 62, 4031 - 4045. https://doi.org/10.1080/00207543.2023.2253328.
54. Kadzamira M, Ogunmodede A, Duah S, Romney D, Clottey V, Williams F (2023): African agri-entrepreneurship in the face of the COVID-19 pandemic. *Cabi Agriculture and Bioscience* 4. https://doi.org/10.1186/s43170-023-00157-3.
55. Kanike U (2023): Factors disrupting supply chain management in manufacturing industries. *Journal of Supply Chain Management Science*. https://doi.org/10.18757/jscms.2023.6986.
56. Laborde D, Martin W, Vos R (2021): Impacts of COVID-19 on global poverty, food security, and diets: Insights from global model scenario analysis. *Agricultural Economics (Amsterdam, Netherlands)* 52, 375 - 390. https://doi.org/10.1111/agec.12624.
57. Lawal O (2022): COVID-19 risks and systemic gaps in Nigeria: resilience building lessons for pandemic and climate change management. *Sn Social Sciences* 2. https://doi.org/10.1007/s43545-022-00557-8.
58. Leddy A, Weiser S, Palar K, Seligman H (2020): A conceptual model for understanding the rapid COVID-19–related increase in food insecurity and its impact on health and healthcare. *The American Journal of Clinical Nutrition* 112, 1162 - 1169. https://doi.org/10.1093/ajcn/nqaa226.
59. Liu H, Shen D, Dabić M, Lu J (2025): A Novel Methodology for Risk Assessment Considering Risk Higher Order Interactions and Propagation Effects. *IEEE Transactions on Engineering Management* 72, 907-924. https://doi.org/10.1109/tem.2025.3534687.
60. Liu L, Zhou X, Xu J (2024): Does working capital management improve financial performance in China's agriculturalfood sector during COVID-19? A comparison with the 2008 financial crisis. *PLOS ONE* 19. https://doi.org/10.1371/journal.pone.0300217.
61. Liu N, Ren S (2024): Production disruption in supply chain systems: impacts on consumers, supply chain agents and society. *Ann. Oper. Res.* 344, 965-988. https://doi.org/10.1007/s10479-023-05782-9.

62. Lopes G, Rossetto C, De Oliveira M, Sausen J, Da-Rocha R. (2023). The structure of a strategic crisis management model: The context and characteristics of a Brazilian community college. *International Journal of Disaster Risk Reduction*. https://doi.org/10.1016/j.ijdrr.2023.103555.
63. Lopez-Ridaura S, Sanders A, Barba-Escoto L, Wiegel J, Mayorga-Cortes M, Gonzalez-Esquivel C, García-Barcena TS (2021): Immediate impact of COVID-19 pandemic on farming systems in Central America and Mexico. Agricultural Systems 192, 103178.
64. Marsden A, Zander K, Lassa J (2023): Smallholder Farming during COVID-19: A Systematic Review Concerning Impacts, Adaptations, Barriers, Policy, and Planning for Future Pandemics. *Land*. https://doi.org/10.3390/land12020404.
65. Martínez-Azúa B, López-Salazar P, Sama-Berrocal C (2021): Impact of the COVID-19 Pandemic on AgriculturalFood Companies in the Region of Extremadura (Spain). *Agronomy* 11, 971. https://doi.org/10.3390/AGRONOMY11050971.
66. Mastronardi L, Cavallo A, Romagnoli L (2021): How did Italian diversified farms tackle Covid-19 pandemic first wave challenges? *Socio-Economic Planning Sciences* 82, 101096 - 101096. https://doi.org/10.1016/j.seps.2021.101096.
67. Mishrif A, Khan A (2023): Technology adoption as survival strategy for small and medium enterprises during COVID-19. *Journal of Innovation and Entrepreneurship* 12, 1-23. https://doi.org/10.1186/s13731-023-00317-9.
68. Montenegro LD, Young MN (2020): Operational challenges in the food industry and supply chain during the COVID-19 pandemic: A literature review. In 2020 7th International Conference on Frontiers of Industrial Engineering (ICFIE) (pp. 1-5). IEEE.
69. Moretto A, Caniato F (2021): Can Supply Chain Finance help mitigate the financial disruption brought by Covid-19? Journal of Purchasing and Supply Management 27(4), 100713.
70. Munonye J, Osuji E, Olaolu M, Okoisu A, Obi J, Eze G, Ibrahim-Olesin S, Njoku L, Amadi M, Izuogu C, Azuamairo G (2022): Perceived Effects of COVID-19 Pandemic on Food Security in Southeast Nigeria. https://doi.org/10.3389/fsufs.2022.936157.
71. Nganu M, Kalei A, Kilonzo T (2024): Effects of Covid-19 Pandemic on Performance of Micro and Small Enterprises (MSEs): A Case of AgriculturalBusinesses in Machakos County, Kenya. *Journal of Business and Management Studies*. https://doi.org/10.32996/jbms.2024.6.4.8.
72. Nnadozie A, Smiles U, Kadurumba C (2018): Role of transportation and marketing in enhancing agricultural production in Ikwo local government area of Ebonyi state, Nigeria. *Sustainability, Agri, Food and Environmental Research*. https://doi.org/10.7770/safer-v0n0-art1353.
73. Nordhagen S, Igbeka, U, Rowlands H, Shine RS, Heneghan E, Tench J (2021): COVID-19 and small enterprises in the food supply chain: Early impacts and implications for longer-term food system resilience in low-and middle-income countries. World Development 141, 105405.
74. Nwahia O, Balogun O, Balogun O, Emeghara U, Onwegbunam N, Bala U (2020): Analysis of technical, allocative and economic efficiency of rice farmers in Ebonyi state, Nigeria. *Russian Journal of Agricultural and Socio-Economic Sciences* 106, 135-143. https://doi.org/10.18551/rjoas.2020-10.15.
75. Ogbodo S, Aliegba E, Ruth C (2023): Effects of budgetary processes in enhancing agricultural development in Ebonyi state. *African Journal of Politics and Administrative Studies*. https://doi.org/10.4314/ajpas.v16i1.9.
76. Ogiji V, Udoikah J (2025): Assessing Water Scarcity on Food Security in Ebonyi State: A Study of Ikwo Local Government Area. *NG Journal of Social Development*. https://doi.org/10.4314/ngjsd.v17i2.9.

77. Okereke CO (2012): Challenges of risk management among smallholder farmers in Ebonyi State, Nigeria: Implications for national food security. Intl. J. of Agric. Econs. and Rur. Dev. 2012, 5 (1), 20
78. Olhager J, Pashaei S, Sternberg H (2015): Design of global production and distribution networks: A literature review and research agenda. International Journal of Physical Distribution & Logistics Management 45, 1/2, 138-158. https://doi.org/10.1108/IJPDLM-05-2013-0131
79. Onyeaka H, Tamasiga P, Nkoutchou H, Guta A (2022): Food insecurity and outcomes during COVID-19 pandemic in sub-Saharan Africa (SSA). *Agriculture & Food Security* 11. https://doi.org/10.1186/s40066-022-00394-1.
80. Onyeneke RU, Mark UA, Chukwudi LN, Emeka EO (2021): Climate Change Perception and Uptake of Climate-Smart Agriculture in Rice Production in Ebonyi State, Nigeria. Atmosphere 12(11), 1503-. doi: 10.3390/ATMOS12111503
81. Oyim A, Osayi K, Okaforocha C, Nwokoye E (2023): Constraints to Agricultural Productivity in South East Nigeria: Evidence from Small-Scale Farmers in Abakaliki Metropolis. *International Journal of Research and Innovation in Social Science*. https://doi.org/10.47772/ijriss.2023.701122.
82. Özşuca E (2024): Agribusiness resilience during the COVID-19 pandemic: The role of credit constraints. *Agricultural Economics (Zemědělská ekonomika)*. https://doi.org/10.17221/56/2024-agricecon.
83. Pedauga L, Sáez F, Delgado-Márquez B (2021): Macroeconomic lockdown and SMEs: the impact of the COVID-19 pandemic in Spain. *Small Business Economics* 58, 665 - 688. https://doi.org/10.1007/s11187-021-00476-7.
84. Rahman M, Abdelfattah F, Bag S, Gani M (2022): Survival strategies of SMEs amidst the COVID-19 pandemic: application of SEM and fsQCA. *Journal of Business & Industrial Marketing*. https://doi.org/10.1108/jbim-12-2020-0564.
85. Ravera F, Dziza K, Santini E, Cristofolini L, Liggieri L (2021): Emulsification and emulsion stability: The role of the interfacial properties. Advances in Colloid and Interface Science 288, 102344.
86. Reardon T, Bellemare MF, Zilberman D (2020): How COVID-19 may disrupt food supply chains in developing countries. IFPRI book chapters, 78-80.
87. Reardon T, Tschirley D, Liverpool-Tasie LSO, Awokuse T, Fanzo J, Minten B, Popkin BM (2021): The processed food revolution in African food systems and the double burden of malnutrition. Global food security 28, 100466.
88. Roner C, Tomasi C (2024): Survival in export markets: experience, export spillovers and productivity. *Journal of Industrial and Business Economics*. https://doi.org/10.1007/s40812-024-00332-1.
89. Sachan A, Datta S (2005): Review of supply chain management and logistics research. International Journal of Physical Distribution & Logistics Management 35(9), 664-705.
90. Sama-Berrocal C, Martínez-Azúa B (2022): How Has the COVID-19 Pandemic Affected the Different Branches of the Agricultural Food Industry in Extremadura (Spain)? *Land*. https://doi.org/10.3390/land11060938.
91. Semenova T, Sokolov I (2025): Theoretical Substantiation of Risk Assessment Directions in the Development of Fields with Hard-to-Recover Hydrocarbon Reserves. *Resources*. https://doi.org/10.3390/resources14040064.
92. Senin S, Juhdi N, Omar A, Hashim N (2024): Small and medium enterprises survival during the global crises: a systematic review of theoretical perspectives of building resilience in the time of crisis. *Cogent Business & Management* 11. https://doi.org/10.1080/23311975.2024.2395428.

93. Shahzad K, Zhang Q, Ashfaq M, Zafar A, Ahmad B (2024): Pre- to post-adoption of blockchain technology in supply chain management: Influencing factors and the role of firm size. *Technological Forecasting and Social Change*. https://doi.org/10.1016/j.techfore.2023.122989.
94. Singh P, Chahal H (2015): Reactive Crisis Management Model. *Journal of Research in Business, Economics and Management* 4, 249-255.
95. Smith MD, Wesselbaum D (2020): COVID-19, food insecurity, and migration. The Journal of nutrition, 150(11), 2855-2858.
96. Swinnen J, McDermott J (2020): COVID-19 and global food security. EuroChoices, 19(3), 26-33.
97. Thompson R, George M (1984): A stochastic investment model for a survival conscious firm. *Annals of Operations Research* 2, 157-182. https://doi.org/10.1007/BF01874737.
98. Torero M (2020): Without food, there can be no exit from the pandemic. Nature, 580(7805), 588-589.
99. Tukamuhabwa B, Stevenson M, Busby J, Zorzini M (2015): Supply chain resilience: definition, review and theoretical foundations for further study. *International Journal of Production Research* 53, 5592 - 5623. https://doi.org/10.1080/00207543.2015.1037934.
100. Vasickova V (2020): Crisis Management Process - A Literature Review and a Conceptual Integration. *Acta Oeconomica Pragensia* 27(3-4): 61-77. https://doi.org/10.18267/j.aop.628.
101. Valaskova K, Durana P, Adamko P (2021): Changes in Consumers' Purchase Patterns as a Consequence of the COVID-19 Pandemic. *Mathematics*. https://doi.org/10.3390/math9151788.
102. Varshney D, Kumar A, Mishra A, Rashid S, Joshi P (2021): India's COVID-19 social assistance package and its impact on the agriculture sector. *Agricultural Systems* 189, 103049 - 103049. https://doi.org/10.1016/j.agsy.2021.103049.
103. Wang H, Wang Z, Dong Y, Chang R, Xu C, Yu X, Zhang S, Tsamlag L, Shang M, Huang J, Wang Y, Xu G, Shen T, Zhang X, Cai Y. (2020). Phase-adjusted estimation of the number of Coronavirus Disease 2019 cases in Wuhan, China. Cell Discovery, 6(1), 1-8. https://doi.org/10.1038/s41421-020-0148-0
104. Wang Q, Rossignoli C, Dompreh E, Su J, Griffiths D, Htoo K, Nway H, Akester M, Gasparatos A (2024): Diversification strategies have a stabilizing effect for income and food availability during livelihood shocks: Evidence from small-scale aquaculture-agriculture systems in Myanmar during the COVID-19 pandemic. *Agricultural Systems*. https://doi.org/10.1016/j.agsy.2024.103935.
105. Weersink A, Von-Massow M, Bannon N, Ifft J, Maples J, McEwan K et al (2020): COVID-19 and the agriculturalfood system in the United States and Canada. *Agricultural Systems* 188, 103039 - 103039. https://doi.org/10.1016/j.agsy.2020.103039.
106. Zellner A (1962): An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias. Journal of the American Statistical Association 57(298): 348–368.
107. Zharare S, Mashingaidze N (2020): Impact of COVID-19 on agribusinesses for investors. https://doi.org/10.1079/20240191154.